



Center for Western Weather
and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY
AT UC SAN DIEGO

ATMOSPHERIC RIVER RECONNAISSANCE: FILLING KEY GAPS

4 AUGUST 2020

PRESENTED BY ANNA WILSON – CW3E/SCRIPPS/UCSD

SEVENTH ANNUAL FORECAST INFORMED RESERVOIR OPERATIONS WORKSHOP

UC San Diego



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Center for Western Weather
and Water Extremes

ATMOSPHERIC RIVER RECONNAISSANCE: SUPPORTING WESTERN STORM PREDICTIONS AND WATER DECISIONS

F. Martin Ralph, PI (UC San Diego/SIO/CW3E)

Vijay Tallapragada Co-PI (NOAA/NWS/NCEP)

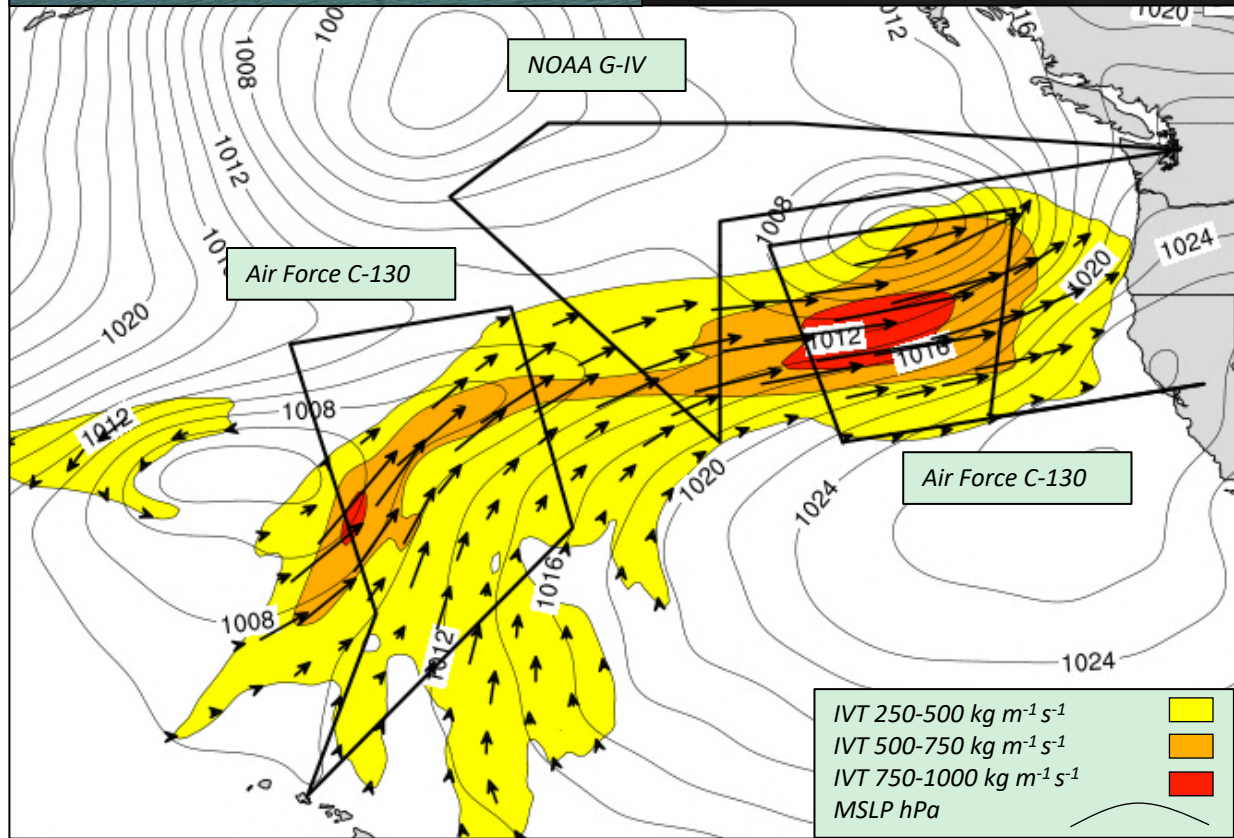
Jim Doyle (Naval Research Laboratory)



Air Force C-130



NOAA G-IV



National Winter Season Operations Plan Includes AR Reconnaissance Off the U.S. West Coast Starting in 2020

In Spring 2019, the interagency group that develops the NWSOP approved incorporation of AR Recon as a leading priority for addressing gaps in west coast storm prediction, specifically targeting ARs and their vicinity over the Pacific with NOAA and Air Force Recon capabilities.

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

1325 East-West Highway, SSMC2
Silver Spring, Maryland 20910
301-628-0112

NATIONAL WINTER SEASON OPERATIONS PLAN

FCM-P13-2019
Washington, D.C.
June 2019

Image of 2018 winter storm courtesy of NOAA

FOREWORD

The purpose of the National Winter Seasons Operations Plan (NWSOP) is to coordinate the efforts of the Federal meteorological community to provide enhanced weather observations of severe Winter Storms impacting the coastal regions of the United States. This plan focuses on the coordination of requirements for Winter Season reconnaissance observations provided by the Air Force Reserve Command's (AFRC) 53rd Weather Reconnaissance Squadron (53 WRS) and NOAA's Aircraft Operations Center (AOC).

The goal is to improve the accuracy and timeliness of severe Winter Storm forecasts and warning services provided by the Nation's weather service organizations. These forecast and warning responsibilities are shared by the National Weather Service (NWS), within the Department of Commerce (DOC) and the National Oceanic and Atmospheric Administration (NOAA); and the weather services of the United States Air Force (USAF) and the United States Navy (USN), within the Department of Defense (DOD).

Within the organizational infrastructure of the Office of the Federal Coordinator for Meteorological (OFCM) services and supporting research, the Working Group for Winter Seasons Operations (WGWSO) is responsible for maintaining the plan. This year marks the 34th edition of the National Winter Seasons Operations Plan (NWSOP).

The national Winter Season mission is a team effort, and as we strive to be a "Weather-Ready Nation," the effective coordination of the Federal agencies involved, local emergency managers, and others help, through improved forecast and warning services, to protect lives and property and reduce our Nation's vulnerability to these high-impact events.

//SIGNED//

David L. Chorney,
Executive Secretary
Working Group for Winter Season Operations and Research

CHAPTER 1 RESPONSIBILITIES OF COOPERATING AGENCIES

1.1 General

Every year, Winter storms threaten lives and property, and cause significant disruptions to travel and commerce. However, accurate forecasts can mitigate the disruption, allowing more time for local officials and the general public to plan for these events. Large forecast errors can occur when observations, in certain upstream "sensitive" regions over the Pacific, Gulf of Mexico, and Western Atlantic, are lacking or inaccurate. The main purpose of Winter Season Reconnaissance (WSR) is to collect data in these "sensitive" oceanic regions where conventional upper-air observations are lacking and satellites are unable to effectively resolve the vertical structure of the atmosphere (usually within cloudy regions). The data collected from the WSR program by the NOAA G-IV and US Air Force WC-130 aircraft are transmitted to operational forecast centers, and assimilated into global numerical prediction models.

The Western United States is extremely susceptible to water shortages and surpluses. These conditions pose a significant risk to the public, property, and commerce as well as numerous Department of Defense (DoD) interests both in wartime readiness and Defense Support of Civil Authorities (DSCA) along the West Coast. The intent of atmospheric river (AR) reconnaissance is to support water management decisions and flood forecasting through the execution of targeted airborne dropsonde and buoy observations over the Central and Eastern Pacific Ocean to improve forecasts of the landfall and impacts of ARs for civil authorities and DoD decision makers along the U.S. West Coast (Reference Appendix H for further technical background). Operations for AR reconnaissance occur from November through March and utilizes two USAF WC-130s and the NOAA G-IV aircraft from up to three different locations when approved and subject to aircraft availability. Operations include the sampling of ARs (and associated atmospheric features) with three aircraft simultaneously to capture full atmospheric and oceanic profiles for integration into numerical weather prediction models (Figure 1.1).

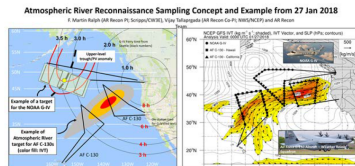


Figure 1.1. AR Recon targeting concept and example using 3 aircraft, executed on 27 Jan 2018. In addition, most adjacent methods is used to identify regions of large initial condition error impacts, which largely match the location of the AR.

During an AR scenario, aircraft operations may begin as early as five days prior to landfall and will end at the point of AR landfall. The frequency of flights during operations is dependent upon the scenario as well as the needs of forecast models, however, may include up to daily flights of each aircraft sampling the feature centered around 0000 UTC. During operations, an AR Recon Flight Planning Mission Director identifies important AR events to observe and provides flight tracks and data collection requirements via either the NWS Western Region Meteorological Services Director, EMC representative or WPC representative to the Senior Duty Meteorologist (SDM) at NCEP Central Operations. CARC-AH works with the SDM to determine the ability of reconnaissance units to meet requirements, considering the availability of resources with mission requirements and incorporates tasked requirements into the Plan of the Day (POD).

The WSR program in the Pacific basin focuses on targeting large-scale extratropical systems that could potentially influence major weather events downstream. These events are predicted to affect the continental U.S. in medium-range time scales on the order of about three to six days by the global models, but with a large degree of uncertainty. The Pacific missions generally require deployments of staff and equipment from the NOAA Aircraft Operations Center (AOC) and the U.S. Air Force Reserve (USAFR) Command's 53rd Weather Reconnaissance Squadron (WRS) to remote operating bases. For the Gulf and Atlantic area of responsibility, the program concentrates on targeting specific weather systems containing a defined central core that have the potential to rapidly intensify and cause major impacts to heavily populated areas in the Eastern U.S. These WSR missions are executed on short-range time scales within 72 hours of the forecasted impact. The 53rd WRS flies the Gulf of Mexico and Western Atlantic missions from its headquarters at Keesler Air Force Base in Biloxi, MS, and deployments are not necessary.



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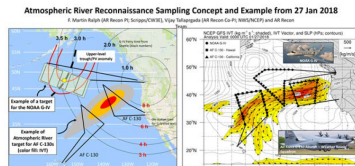


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AR Recon represents a Research And Operations Partnership



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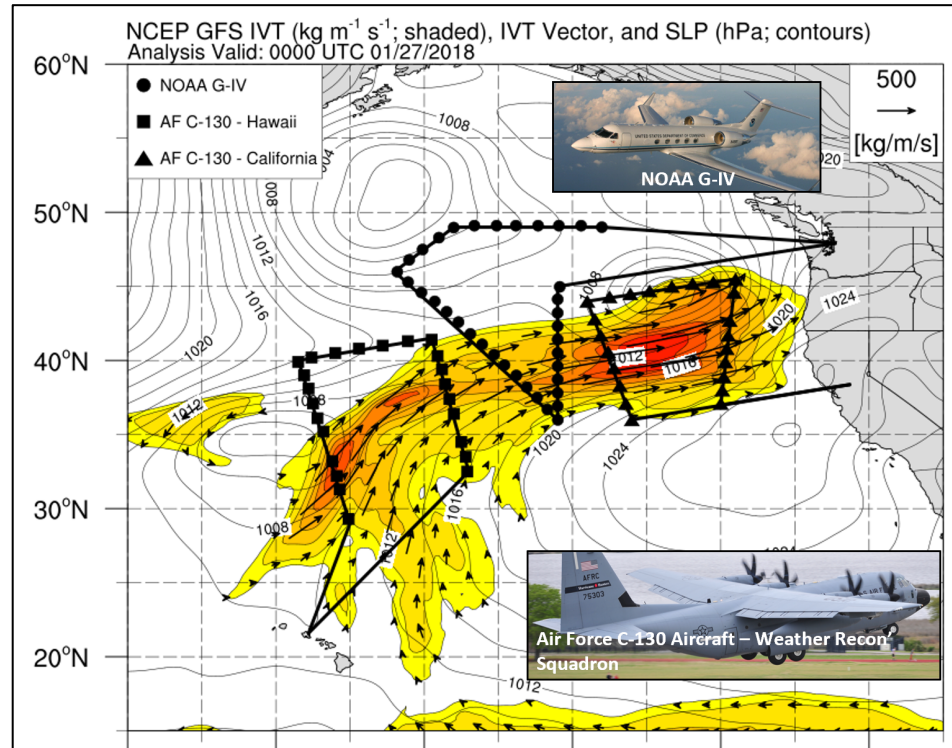
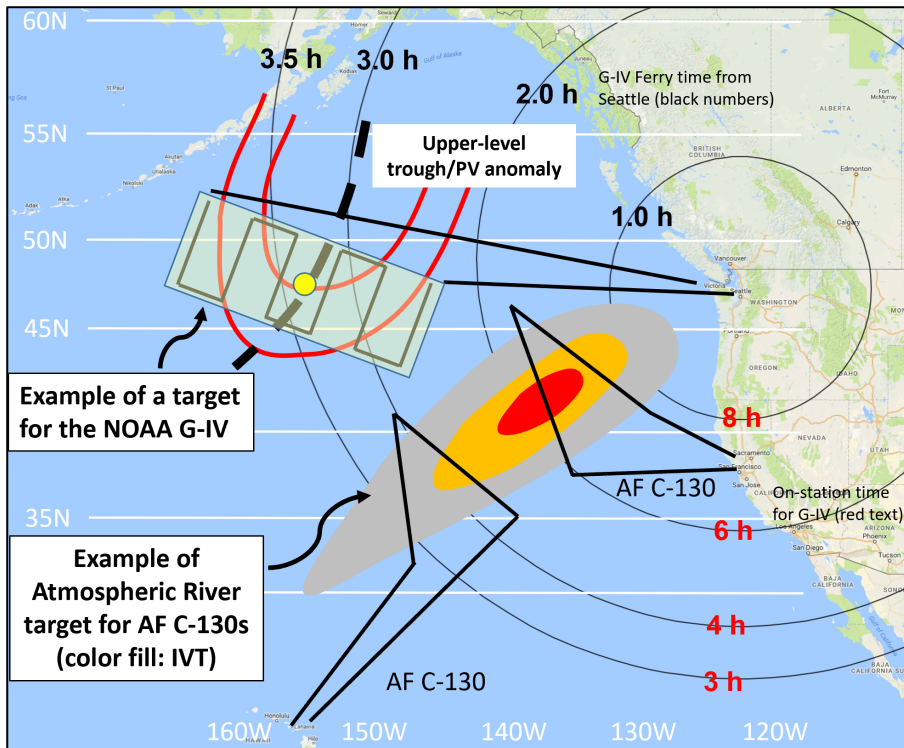
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Atmospheric River Reconnaissance Sampling Concept and Example from 27 Jan 2018

F. Martin Ralph (AR Recon PI; Scripps/CW3E), Vijay Tallapragada (AR Recon Co-PI; NWS/NCEP) and AR Recon Team



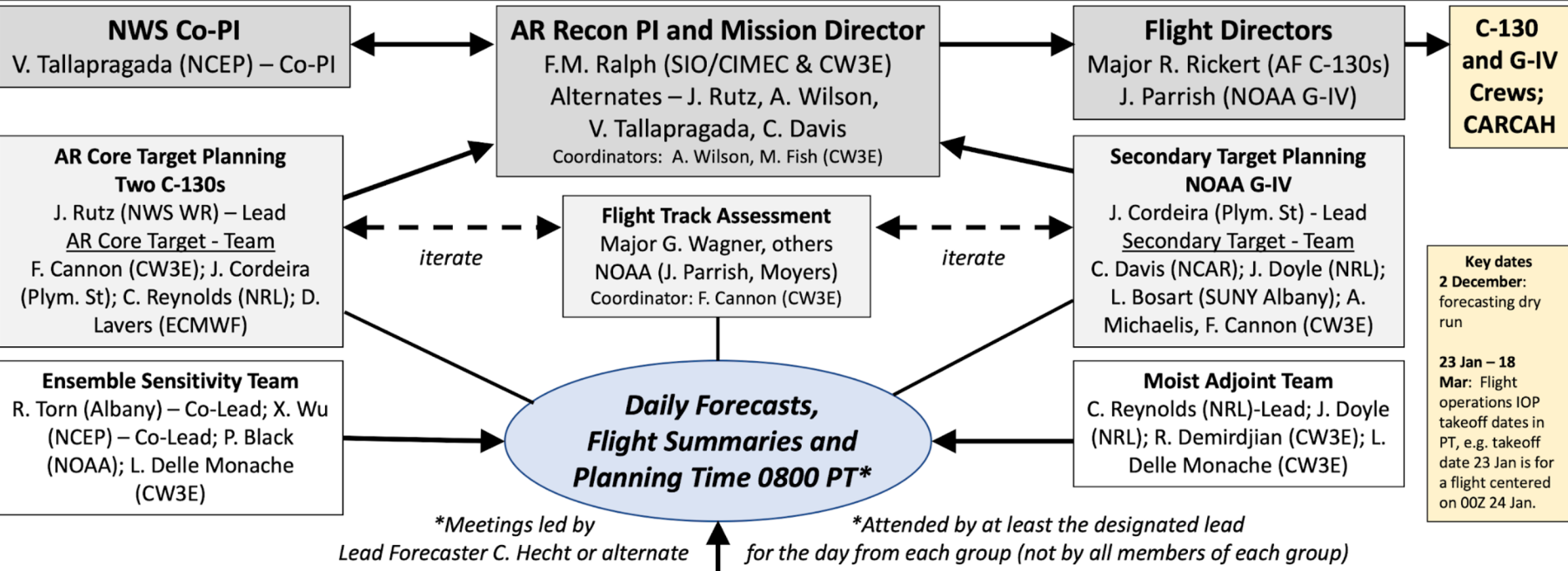
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AR Recon – 2020 Flight Operations Planning and Execution



AR Recon – 2020 Flight Operations Planning and Execution

NWS Co-PI

V. Tallapragada (NCEP) – Co-PI

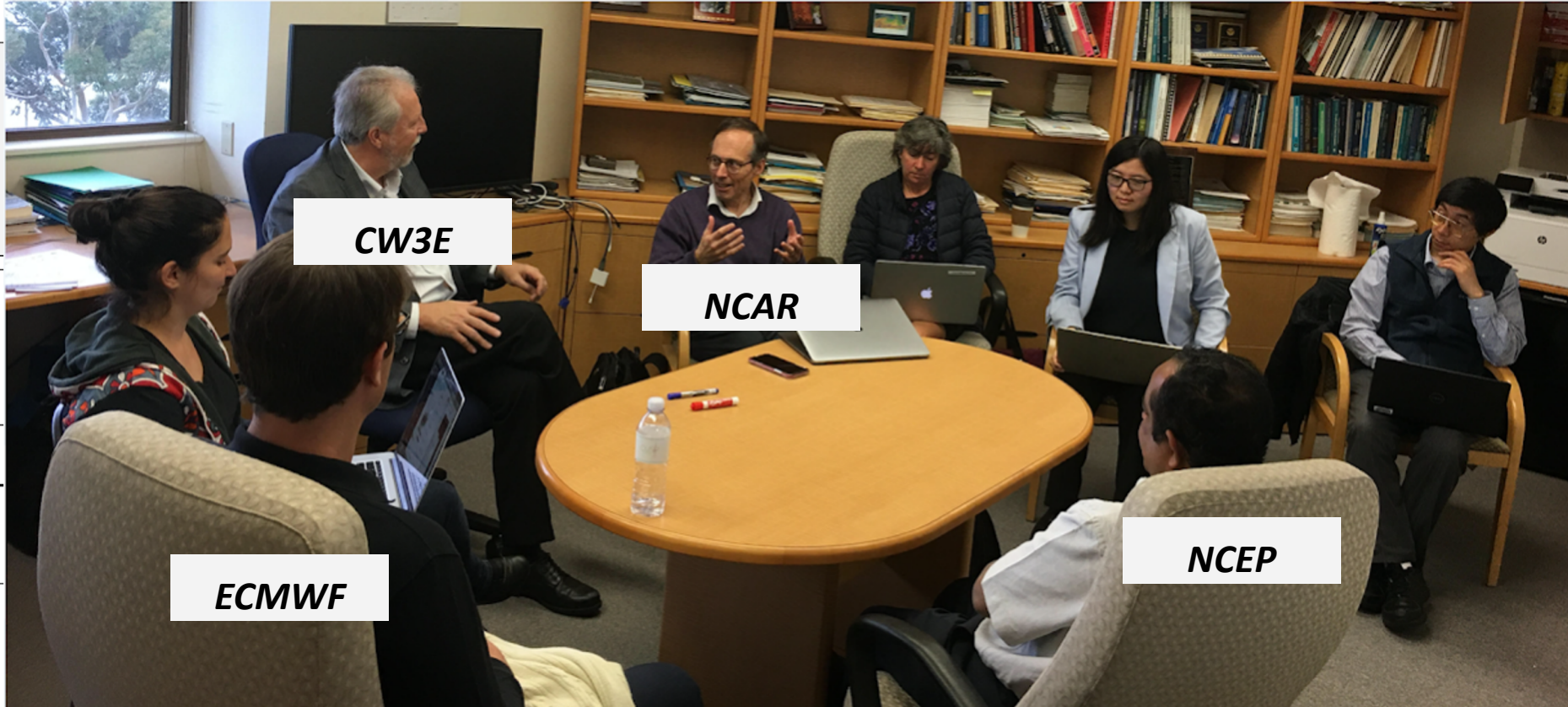
AR Recon PI and Mission Director

F.M. Ralph (SIO/CIMEC & CW3E)

Flight Directors

Major R. Rickert (AF C-130s)

**C-130
and G-IV
Crews**



AR Recon – 2020 Flight Operations Planning and Execution

NWS Co-PI

V. Tallapragada (NCEP) – Co-PI

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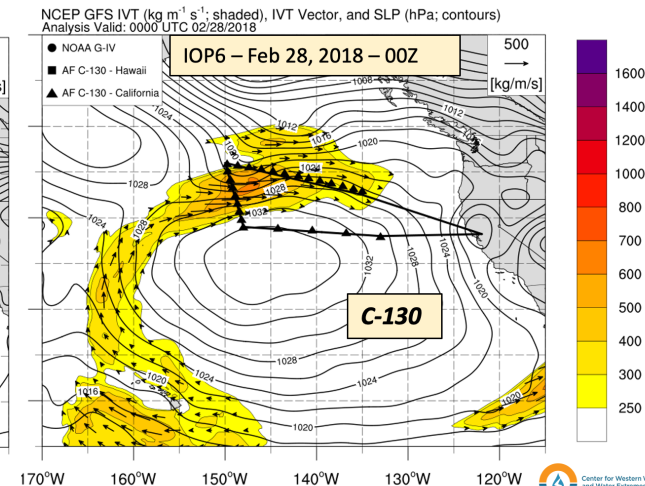
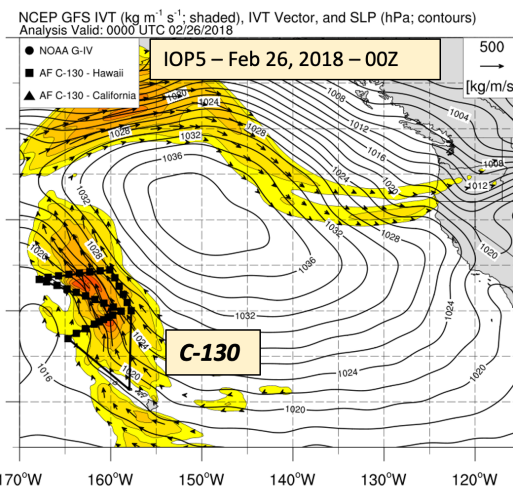
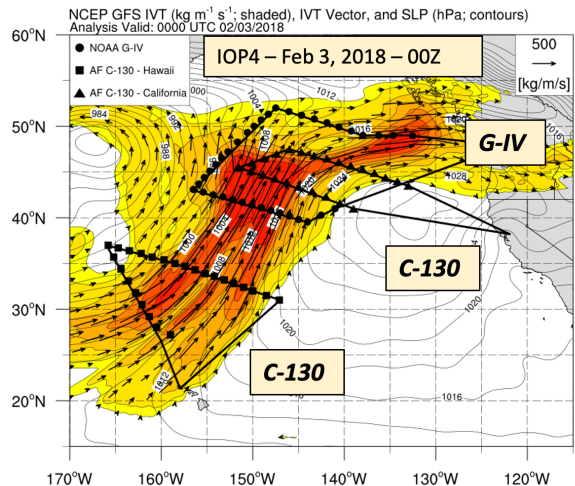
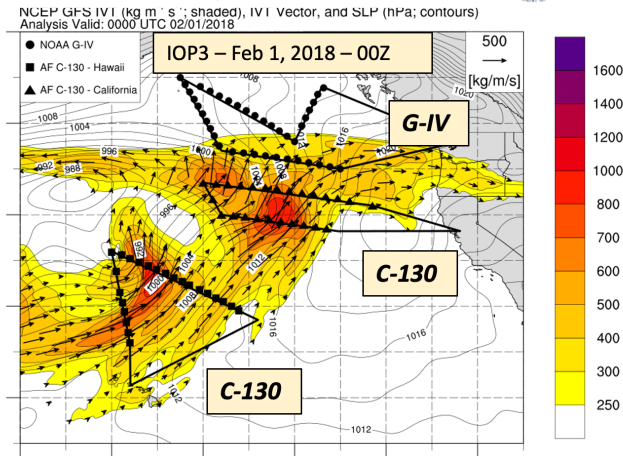
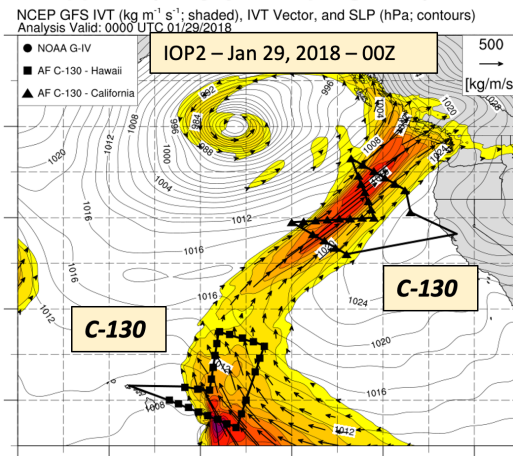
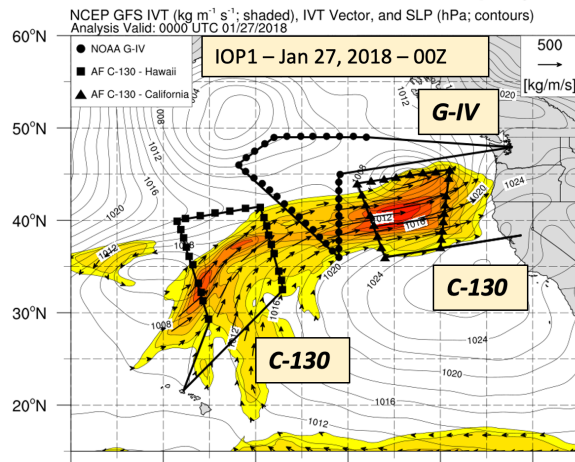
**C-130
and G-IV**





Atmospheric River Reconnaissance 2018, IOPs 1-6

F.M. Ralph (CW3E/Scripps; PI); Vijay Tallapragada (NOAA/NCEP/EMC; Co-PI)

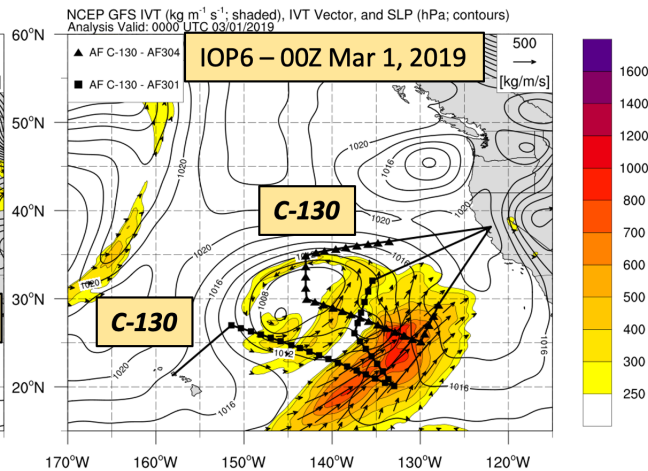
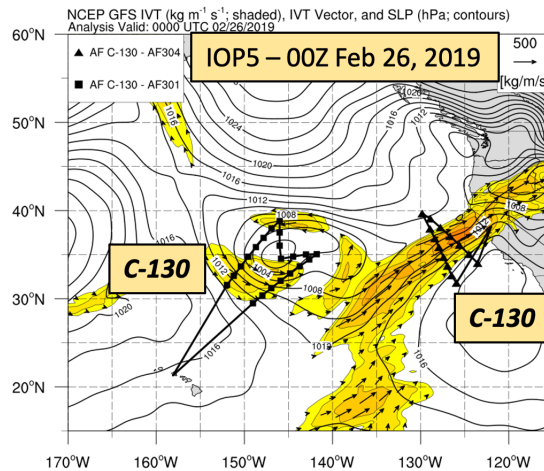
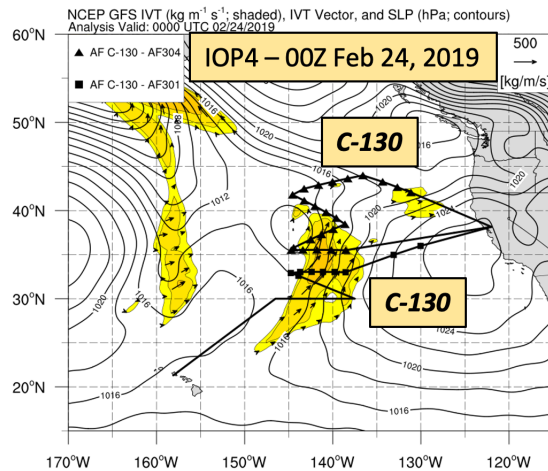
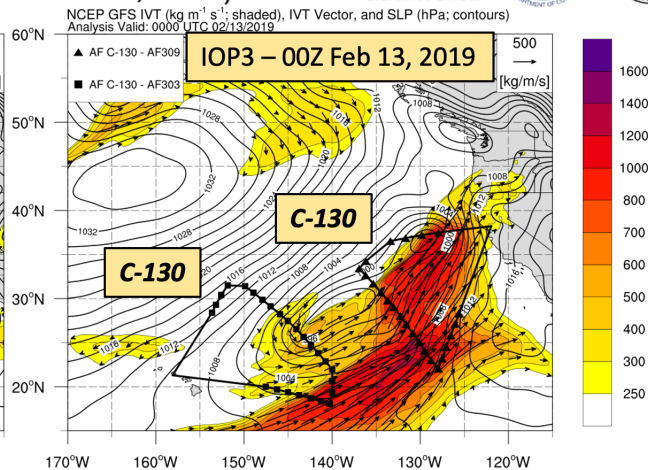
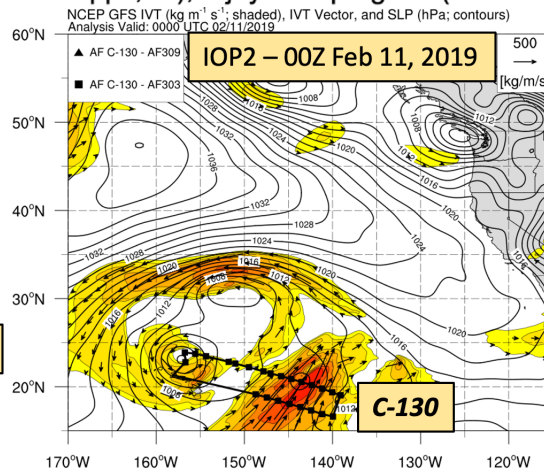
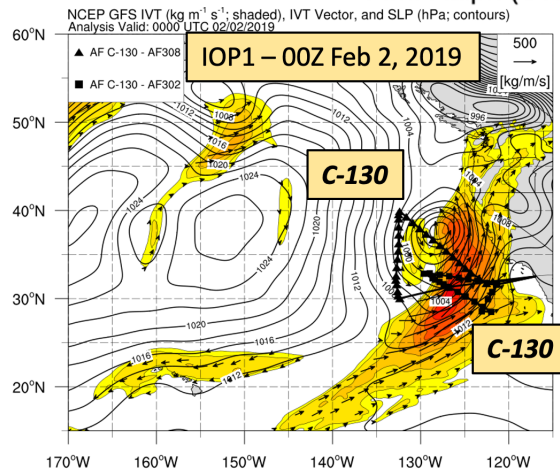


Integrated Vapor Transport ($\text{kg m}^{-1} \text{s}^{-1}$)



Atmospheric River Reconnaissance 2019, IOPs 1-6

F.M. Ralph (CW3E/Scripps; PI); Vijay Tallapragada (NOAA/NCEP/EMC; Co-PI)

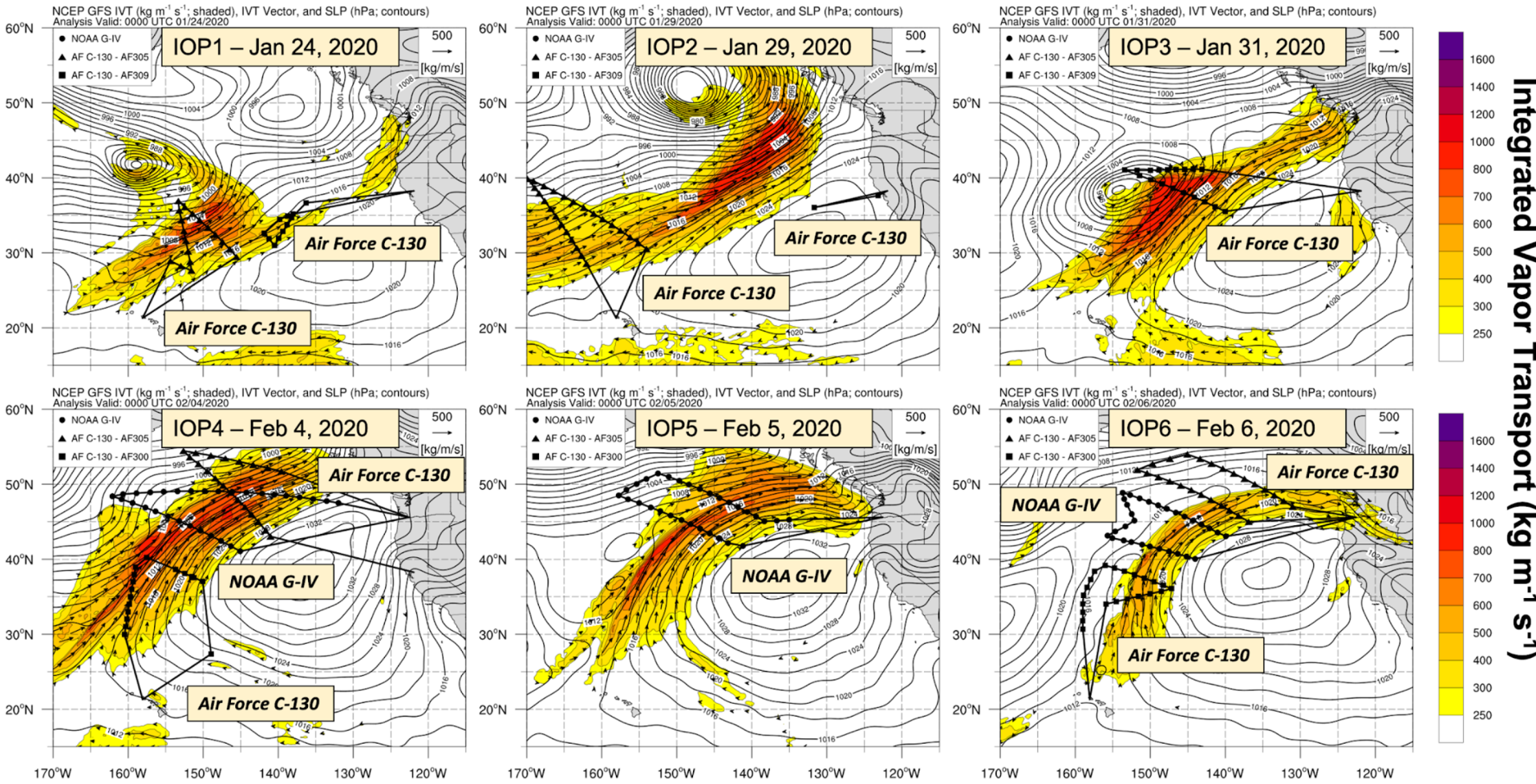


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Atmospheric River Reconnaissance 2020, IOPs 1-6

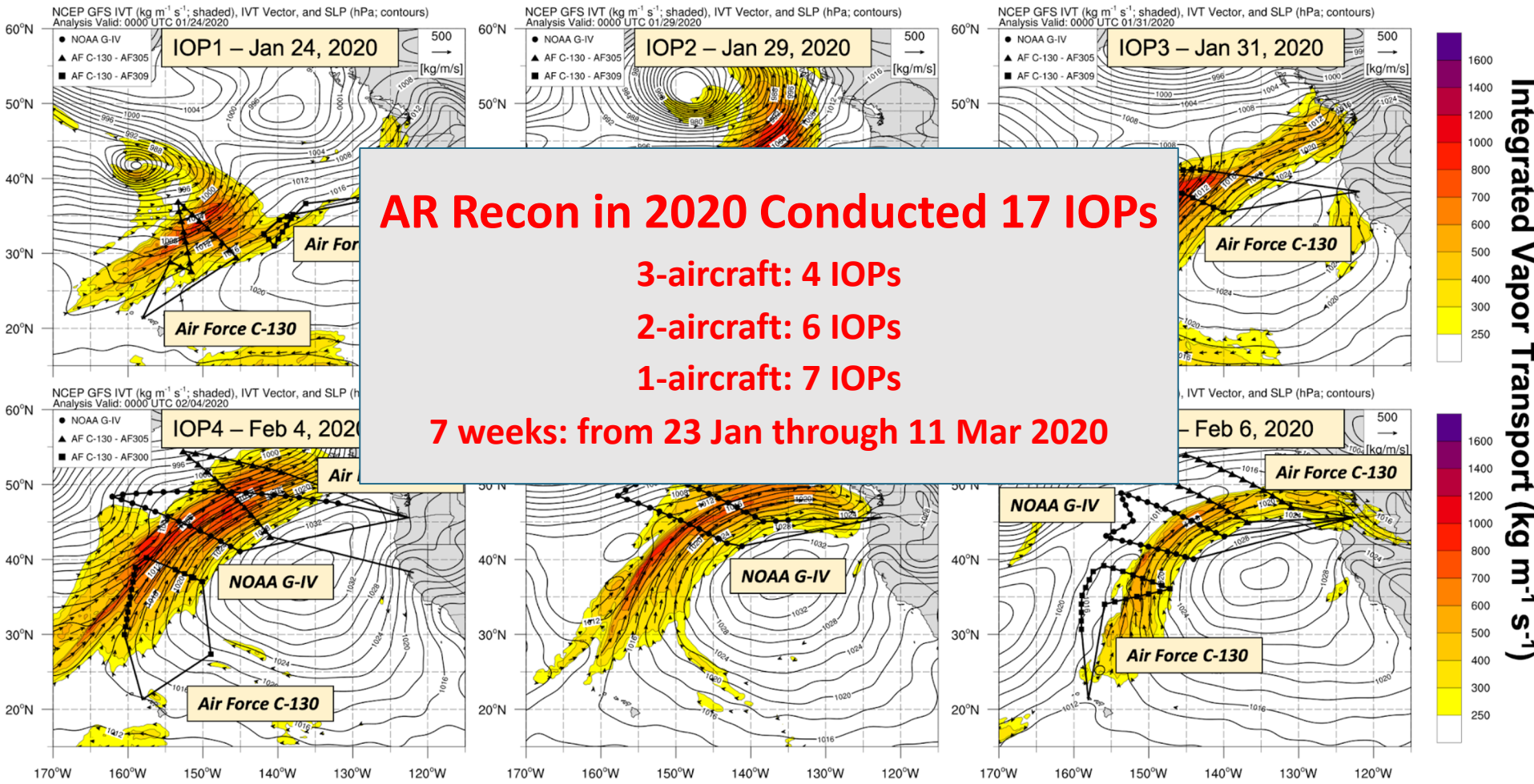
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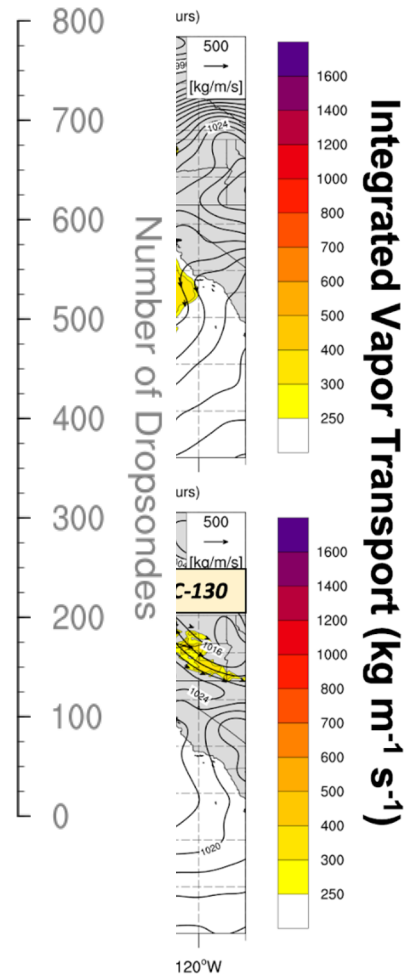
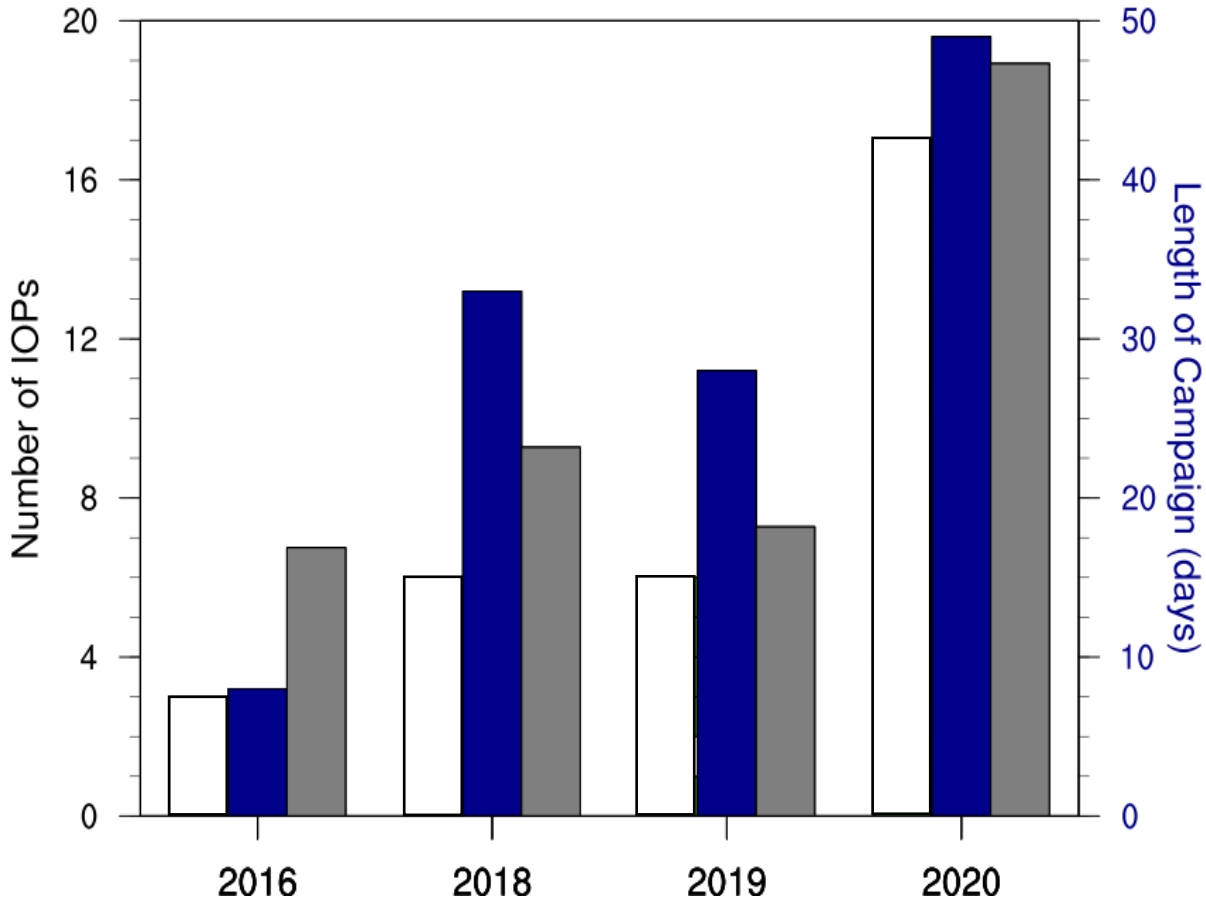
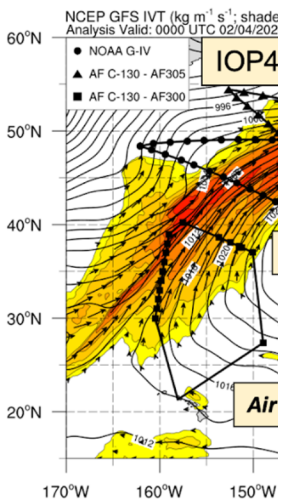
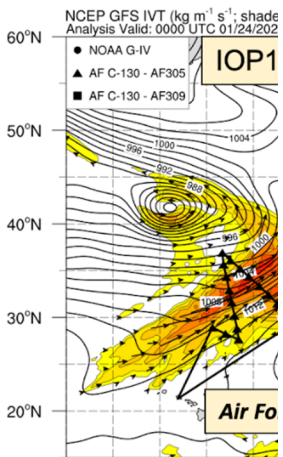
Atmospheric River Reconnaissance 2020, IOPs 1-6

F.M. Ralph (CW3E/Scripps; PI); Vijay Tallapragada (NOAA/NCEP/EMC; Co-PI)





Atmospheric River Reconnaissance



Emerging Technology Testing in AR Recon: Airborne Radio Occultation (ARO)

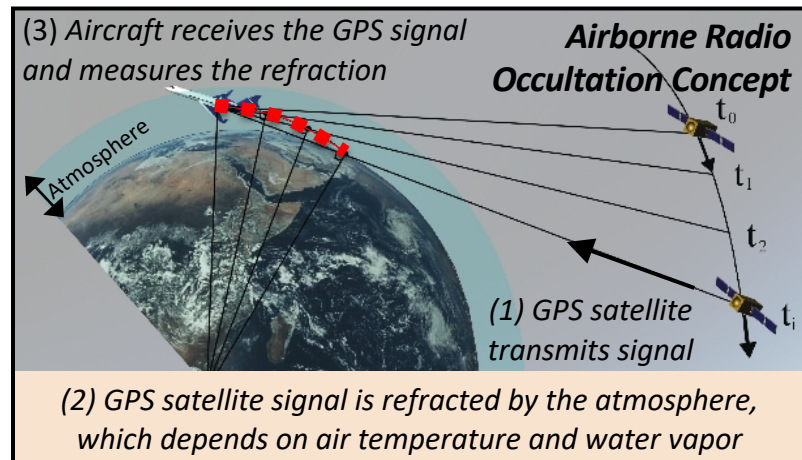
ARO Lead: Jennifer S. Haase (SIO/UCSD)

jhaase@ucsd.edu

**AR Recon-2018 (IOP-1)
27 Jan 2018**

**G-IV
flight
track**

Experimental assimilation of ARO data from
AR Recon into CW3E's West-WRF model
**substantially changes the water vapor (q) up
to 0.5 g/kg and wind up to 5 m/s at ranges of
up to about 300 km from the aircraft.**



AR Recon - 2020 deployment

- 3 aircraft with standard ARO
- 1 aircraft experimental dual-pol ARO hydrometeor information

dual-pol
antenna



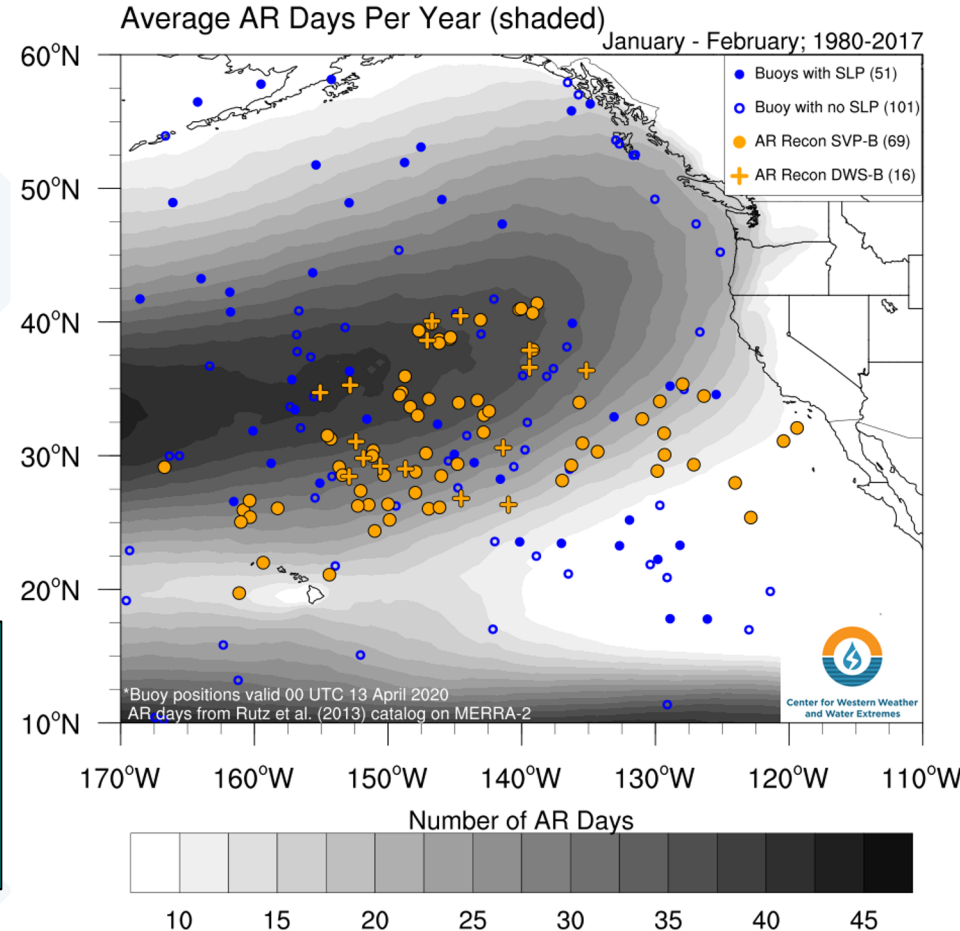
ROC2
Receiver



DRIFTING BUOY WITH PRESSURE SENSORS – AR RECON DEPLOYMENT

- Second year in a row with buoy deployment collaboration between NOAA Global Drifter Program (*PI: Luca Centurioni*), Scripps/CW3E AR Recon (*PI: Marty Ralph*) with planning support from the AR Recon Modeling and DA Steering Committee (*Scripps/CW3E, NCEP, ECMWF, NRL, NCAR, CU Boulder*)
- 2019: 32 buoys air-deployed by Air Force
- 2020: 64 buoys – 40 deployed via ship of opportunity; 24 deployed via Air Force
- Evaluation ongoing

Leverages federal investments by upgrading instrumentation provided through NOAA's Global Drifter Program



MEDIA COVERAGE

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[ENVIRONMENT < https://calmatters.org/category/environment/ >](https://calmatters.org/category/environment/)

Drought or dangerous flooding? Research to save California's rain

BY RACHEL BECKER < <https://calmatters.org/author/rachel-becker/> >
FEBRUARY 25, 2020



Maj. Sonia Walker, 53rd Weather Reconnaissance Squadron aerial reconnaissance weather officer, verifies the dropsonde data is accurate before sending it via satellite to the National Hurricane Center. Photo by Rachel Becker for CalMatters

ENVIRONMENT

Flights Into The Stratosphere Study Changes To Atmospheric Rivers

May 14, 2020 · 5:36 AM ET
Heard on [Morning Edition](#)



NATHAN ROTT

NPR, Morning Edition



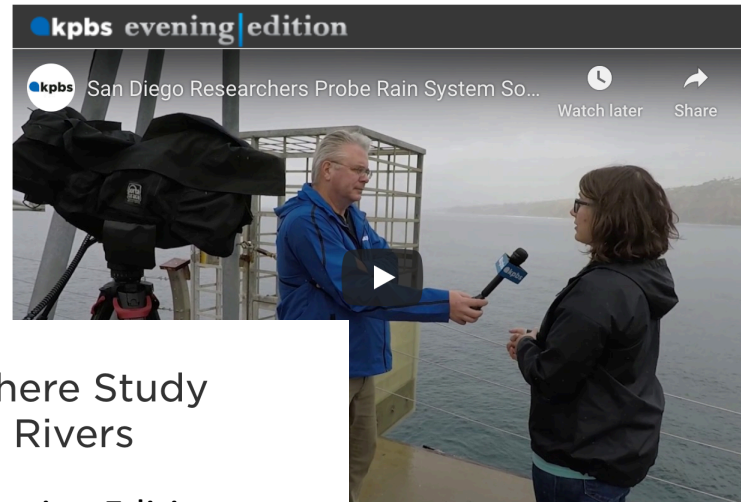
3-Minute Listen

+ PLAYLIST



Scientists are racing to better understand atmospheric rivers, bands of moisture that start in the tropics and can bring torrential rain to the U.S. They're projected to intensify with climate change.

"We're able to get an idea of what is going on inside those cloudy areas that we can't see otherwise," Michaelis said.



REPORTED BY ERIK ANDERSON , VIDEO BY ROLAND LIZARONDO



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Figure 1: From left to right: Nikki Hathaway (NOAA AOC), David Lavers (ECMWF), and Richard Henning (NOAA AOC) on board the NOAA G-IV research aircraft. Credit: Tashiana Osborne.

AR Recon Flight 03/07/2020

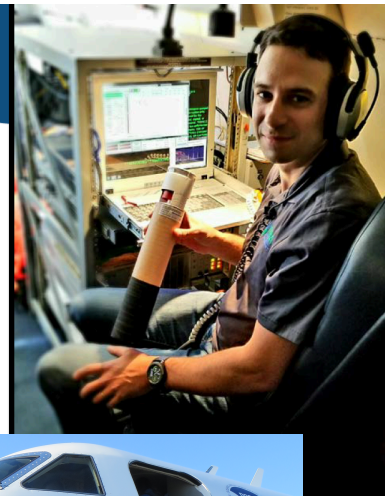


Photo courtesy Cary Talbot



Photo courtesy Jack Parrish



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SUMMARY – AR RECON RESEARCH AND OPERATIONS PARTNERSHIP FILLS KEY GAPS

- Combination of
 - proven technology:
 - critical vertical profile information on wind, temperature, moisture in areas targeted based on forecast sensitivity
 - increased density of surface pressure measurements
 - novel technology:
 - GPS-ARO tangent profiles of moisture and temperature
- Team of experts involved in forecast discussions; designing data denial experiments
- Flight Directors embedded in process

